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PUBLIC WATER-SUPPLY FOR SMALL TOWNS.

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Drinking water that is manifestly bad does not make everyone that uses it sick. Even when the mains and reservoirs of a public water-system have been infected by such a poison as that of typhoid it is only exceptionally and for limited periods that as many as one per cent. of those using the water contract the disease. An outbreak of 2,000 cases in a population of 200,000 is ordinarily regarded as a severe epidemic, and yet this is at the rate of only one person in a hundred. It is this immunity on the part of the great mass of the people that permits infected systems of water-supply to continue in operation. If there were no resisting power on the part of the individual, all would die on the slightest exposure and the source of danger would soon be thoroughly identified and avoided. As it is, however, for every one that contracts the disease there may be as many as a hundred who escape. Thus it becomes a question of probabilities, and there is a chance for much plausible theorising and controversy. Gradually, however, as the result of increasing observation and experience, crude ideas that have prevailed are being eliminated and the truth of the matter established.

Only a few years ago the most essential point in the improvement of water-supply was thought to be the determination of the chemical ingredients held in suspension or solution. Elaborate systems of analysis were devised for this purpose, and the quality of the water was judged almost entirely by its chemical reactions. Thus it became customary to consider the questions involved from a chemical point of view exclusively. The simple dilution of contained matters of a chemical nature, if carried far enough, would make them

harmless. Consequently large bodies of water were supposed to have a power of self-purification in direct proportion to their size. In like manner precipitation, sedimentation, aeration and other chemical and mechanical processes were supposed to have a purifying effect. The quantity of sewage entering a stream being known, it becomes possible to tell with a good degree of certainty at what distance, mingled with such a volume of water, it will become so diluted, diffused and changed as to be unrecognisable by any chemical test. The dose of poisonous matter, if of a chemical nature, ought to be divided and subdivided to such an extent as to be entirely harmless in the quantity of water that any individual would consume. In practice, however, this is not found to be the fact, sewage infection being capable of producing epidemic disease for many miles along a stream entirely out of proportion to any possible chemical process of diffusion.

The whole tendency of modern research has been to show that the question as to the spread of disease through the agency of water is biological rather than chemical. It is the presence of certain living organisms and of the conditions on which their continued existence depends that leads to the spread of disease. A single seed may be the means of overspreading an entire continent with some form of luxuriant growth, and so a single disease germ may start an epidemic, not through any mechanical or chemical process of division or subdivision, but because having life it grows and multiplies.

The danger consists not in the quantity of such organisms but in their power of growth under given conditions. If capable of living in water, they may infect an entire stream instead of disappearing by processes of dilution within a few rods. Unlike chemical poisons, they have no fixed poisonous dose. The smallest possible inoculation may prove fatal through the power of self-propagation which they possess. If, on the other hand, their growth be hindered by unfavorable temperature, moisture, or food supply, they may become harmless no matter what their quantity. It is true that they

have chemical effects, originating substances known as toxines, some of which are deadly poisons, but they themselves depend upon the possession of life for the modes of activity which they exhibit. Throughout it is a question of vitality under particular surroundings.

Typhoid fever, cholera and certain forms of dysentery are the chief diseases whose infection it is generally admitted can live in water. In addition, about ten years ago, the writer came to the conclusion that the term malaria, signifying bad air, is a misnomer, and that diseases of this class are very largely, if not exclusively, conveyed in water. Towns taking their public water-supply from ponds or streams having distinctly malarial surroundings have become subject to such fevers although previously free from them.

The manner of spreading of the diseases which have been named originates two classes of dangers. If water be taken from the vicinity of human habitations there is liability to contamination from excreta washed into the pond or stream used as a source of supply, or, in the case of wells, the strong action of powerful pumps may originate a rapid flow underground extending many hundreds of feet and carrying impurities through coarse gravel or open crevices in the soil. That this is the fact appears from the manner in which ordinary wells at a considerable distance from the pumping station run dry when the latter is in operation. Such contamination from human sources may originate typhoid and diarrheal disorders. If, on the other hand, the source of supply is remote from human habitation there may be malarial contamination. Indeed the natural habitat of malaria is in new and undrained countries and virgin soil. In view of this distribution of the disease it is surprising that well-drained cities, having perfect sewers, should yield a certain percentage of malarial fevers until the source of their water-supply is noted, it being in such cases, as a rule, some pond or stream in whose vicinity these diseases are prevalent. Shallow wells in alluvial soil also may yield malarial infection. It is said that since the substitution of deeper artesian borings

for such wells there has been a notable decrease of malarial diseases in some parts of the Southern States of North America.

In many localities it is difficult, if not impossible, to secure an adequate supply of water free from the forms of contamination to which reference has been made. This necessitates some system of purification.

It has been discovered recently that there is an antagonism between disease germs and what are known as nitrifying organisms, which produce nitrites and nitrates in the soil. Advantage has been taken of this to institute an intermittent process of filtration. Water containing the bacteria that it is desired to destroy is allowed to run into a filter composed of sand, containing an abundance of nitrifying organisms, and instead of being drawn off immediately is allowed to stand for a sufficient length of time to permit the destruction of the disease germs by their natural foes.

Such filtration as that just described is but the perfecting of natural processes. Alternation of rainfall and dry weather operates substantially on the same plan, tending to purify the ground water in the soil from infection and making wells possible. Thus in localities where artificial filter beds are impracticable it may be possible to resort to wells with similar results. Experimental borings are required in order to determine whether the quantity of water is adequate and whether the soil through which it percolates is adapted to secure its purification. This being done and the system established, the intermittent action of the pumps, running a part of each day, like intermittent filtration, yields a much purer supply than could be had in any other way. A point to be guarded against is the influx of surface water, which is specially liable to contain malarial infection as well as other impurities. To this end, numerous small wells, consisting of iron pipes put down to the proper depth and having perforations over a space of six or eight feet from their lower extremities, covered with fine wire gauze, may be employed. Another plan that may serve is to have a single large well, twenty feet or more

in diameter. A convenient method of construction of such a well is by the use of a curb, built up in a hexagonal or octagonal form, of plank laid flatwise and spiked one upon the other in layers. If such a curb be made, slightly smaller toward the top, it can be carried down successfully through almost any sort of soil and stoned up.

It has been thought best to enter somewhat into such details as have been indicated, because they illustrate the principles involved in improvement of water supply, especial reference having been had throughout to localities whose resources are limited. The adaptation of laboratory results to practical uses is the point specially sought to be accomplished in this brief summary. The sanitary engineer, the practising physician and the skilled microscopist are upon common ground in these studies.

At the present stage of progress it must be admitted, however, that serious imperfections are unavoidable in the best systems of water-supply available in many localities. This being the case, household methods of purification require to be taken into the account. That preferred by the writer is as follows: The water is boiled and allowed to stand in a covered stone jar until all sediment has deposited. It is then transferred to ordinary air-tight glass fruit jars, a lot of which, having convenient modes of fastening, are kept for the purpose. When put in an ice chest or cool cellar such water comes out beautifully clear, sparkling and palatable. Such water has no unpleasant flavor unless kept too long, and even this might be avoided by sterilising the jars and filling them with the water while hot, which would require reheating after the sediment is removed. Practically there is no necessity for this extra trouble. Certainly all the waters treated by the writer in this way have proved to be excellent, and there can be no question as to their freedom from the infection of any of the diseases that have been named in the discussion. It may be noted also that substantially the same principle is employed when water is used for quenching thirst in the form of tea, coffee, soups and the like. It is the boil-

ing that makes such waters safe, the various ingredients added serving to please an acquired taste for the most part. Mankind is accustomed to take many precautions of this sort without any clear ideas of the reasons. It is the province of advancing civilisation to enable such precautions to be taken intelligently, and consequently more perfectly, and this is the aim of the present discussion in regard to water-supply.